施用氮肥對水稻抵抗褐飛蝨爲害之影響[1]

鄭　清　煥[2]

病蟲害發生與猖獗，除受天候及天敵因素影響外，植物營養亦被視爲重要因子之一。肥料爲植物營養之重要來源，因此對於施用的肥料種類及施用量與病蟲害發生關係的報告，屢見於農業文獻。在水稻方面，多施氮肥常加重稻熱病、紋枯病、葉鞘腐敗病、及小粒菌核病之發生(4)(2)。肥料用量與二化螟蟲之生育生理關係(6)(7)(3)及對飛蝨、葉蟬類之取食、發育、繁殖等之影響，亦經詳細觀察(10)(14)(16)(17)。一般以多施用氮肥有增加害蟲之取食量、生育及繁殖等現象，水稻受害亦因之更爲嚴重。

最近本分所、國際稻米研究所、及日本研究人員先後觀察水稻品種對褐飛蝨爲害之感受性，發現少數品種具高度之抗蟲特性。褐飛蝨在抗蟲品種棲息蟲數或繁殖量，均遠較在感蟲品種爲低(15)(16)(17)。但此等抗蟲品種之抗蟲性是否受肥料之影響，而減弱其抗蟲特性，尙未見報導。本試驗之目的在於探測氮肥之施用量與褐飛蝨在水稻取食、繁殖及爲害之關係，而尤着重於氮肥對於抗蟲品種之抗性可能發生的影響。玆將所得結果，草成報告，以供參考。尙懇諸同道先進斧正。

本試驗承蒙農復會黃技正正華之鼓勵及贊助，本分所張主任萬來提供意見，及技術員邱顯忠先生之協助，獲益良多，倂表謝忱。

一、試驗材料

本試驗選用水稻 Mudgo (RR)，高秈育12號 (R) 及臺中在來1號 (SS) 等三品種爲材料。土壤則選自本所水源地農場瘦瘠之植質壤土。氮肥以20%硫酸銨，各處理盆栽（盆之直徑12cm，深10cm）土壤混用 1.8g（按 320kg/ha 換算，高氮區）及 0.9g（按 160 kg/ha 換算，中氮區）。另設不施氮肥處理（缺氮區）以資對照。各水稻品種於播種後15天，分別以單株栽植於備妥之盆中。其後每日除灌以自來水外，不加施任何肥料。各項試驗在水稻移植後30天開始進行。此時各品種之每一處理，水稻之分蘗株數、葉色、及發育狀況，差異非常明顯（圖1）。本試驗所用之褐飛蝨，全部爲本分所養蟲室所育之個體。全部試驗在民國59（1970）年9月至11月，依性質分別在網室及實驗室內完成。

圖 1. 供試驗各處理水稻發育狀況

Fig. 1. Photograph showing rice plants preparing for the use of experiment

a/. From left to right, rice plant treated with nitrogen in 320 kg/ha., 160 kg/ha. and N-defeciency.

二、方法與結果

(一) 寄主嗜好性 (Host preference)

如上述準備移植後30日齡水稻，每盆除留其母本一株外，其餘分蘗新株用剪刀去除，其後按裂區設計方法排列。重複5次。每一重複接羽化後2～3日齡長翅型成蟲50對，並用網罩 (60×45×45cm) 罩之。褐飛蝨在每處理水稻之棲息蟲數每24小時紀錄一次，連續5天。

1.試驗報告農試字第五二○號

2.臺灣省農業試驗所嘉義農業試驗分所技士

本試驗結果如表一，水稻品種，不論其抗蟲性如何，其生長在氮區者，均較缺氮區者爲褐飛蝨所喜愛棲息。在三品種中，以高秈育12號差異最爲明顯，其生長在中氮區者，棲息的褐飛蝨數，較生長在缺氮區者增加達17倍之多。在同樣的情況下，蟲數在 Mudgo 者約增加 5 倍，在臺中在來 1 號者增加 6 倍。褐飛蝨在高氮區水稻上之蟲數，未必較在中氮區者增加；相反地，高氮區臺中在來 1 號之蟲數，竟較在中氮區者爲少。綜合上述試驗觀察結果，褐飛蝨在各品種棲息蟲數，雖未必因增施氮肥而增加；但有一點値得注意，即在同一氮肥施用量下，褐飛蝨不喜歡棲息於抗蟲品種的特性並沒有改變。此種特性表現於高度抗蟲品種者，較諸於中等抗蟲品種更爲穩定。

表一　氮肥施用量對褐飛蝨在抗蟲及感蟲性水稻寄主選擇之影響

Table 1. Effect of nitrogen fertilizer on the host preference of brown planthopper in resistant and susceptible rice varieties a/.

品　種 Varieties	各處理區蟲數百分率 Percentage of insect/treatment			合　計 Total
	高氮區 320 kg/ha.	中氮區 160 kg/ha.	缺氮區 N-deficiency	
Mudgo (RR)	7.52	6.94	1.51	15.97
Kaoshen-yu 12 (R)	15.45	15.62	0.89	31.96
T (N) 1 (SS)	18.02	29.22	4.76	52.07
合　計　Total	40.99	51.85	7.16	100.00

LSD	5%	1%
(1) Among nitrogen-levels within a variety or among treatments	3.85	5.25
(2) Among varieties within a nitrogen-level	3.89	5.27
(3) Among nitrogen-levels in total of each varience	6.68	9.72
(4) Among varieties in total of each varience	6.67	9.04

a/. 重複五次，每重複接入成蟲50對。(5 replications, 50 pairs of adult insects were caged each.)

b/. 總蟲數百分率按連續五天記錄計算。(Percentage of total number of insects counted during 5 days.)

(二) 排泄量 (Amount of honeydew excretion)

刺吸式口器昆蟲，如蚜蟲、飛蝨類或黑尾葉蟬類之昆蟲，在寄主上取食或排泄量，常用於測定寄主對該種害蟲之抵抗性。昆蟲在抵抗性寄主之取食或排泄量，均顯著地較在感蟲寄主上者爲低(10)(16)(1)。爲探知氮肥對褐飛蝨在水稻上取食之影響，試驗如圖 2 之裝置，各處理區盆栽水稻，每盆接入 2～3 日齡雌成蟲 5 隻。成蟲在接入各處理區水稻之先，先置於無食物之養蟲箱內 2 小時，使其將腹內之排泄物排出。在接蟲後24小時，成蟲在各處理區取食所排出之甘露 (Honeydew)，被收集於墊在蟲下之濾紙上，在經下列方法處理濾紙後，其排泄量即可資比較。(1)以 Ninhydrin 試藥處理，比較在濾紙上之着色面積及其顏色；(2)經 Ninhydrin 處理之濾紙以80%乙醇抽出，再用比色計比較氨基酸之濃度。

從圖 3，以濾紙上着色面積比較，明顯地顯示褐飛蝨在臺中在來 1 號之排泄量，較在其他品種經同量氮肥處理者爲多。在三種氮肥處理間，褐飛蝨取食於缺氮區水稻上之排泄量，顯然較氮肥處理區稻株上者爲少。從排泄量定量比較結果(表 2)，顯示褐飛蝨在 Mudgo 三種處理的排泄量雖有差異，

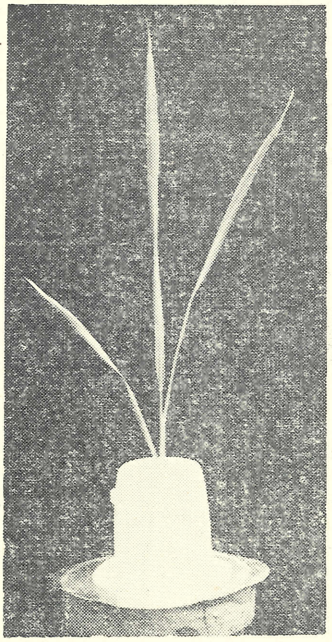


圖 2. 甘露收集裝置
Fig. 2. Apparatus used for collecting honeydew

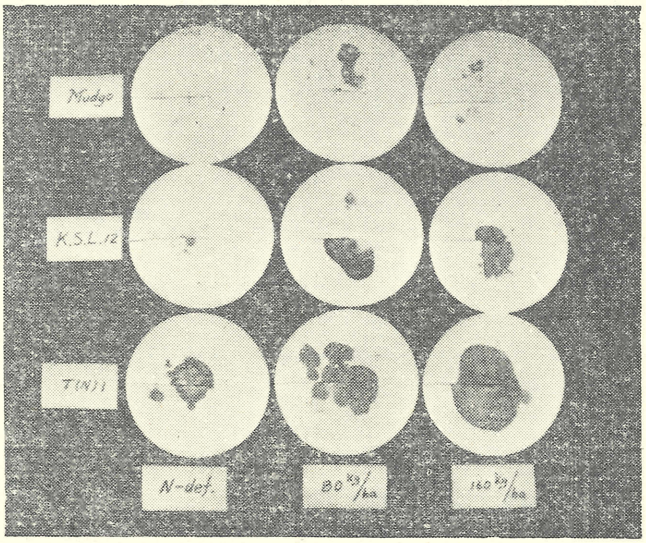


圖 3. 褐飛蝨在不同氮肥處理之抗蟲及感蟲性水稻上甘露排泄量差異之比較
Fig. 3. The amount of honeydew excreted by 5 pairs of brown planthopper adults varied with rice varieties and nitrogen fertilizer applied to rice plant.

表二 施用氮肥於抗蟲及感蟲性水稻對褐飛蝨甘露排泄量之影響

Table 2. Effect of nitrogen fertilizer on the honeydew excretion of brown planthopper on resistant and susceptible rice varieties a/.

品種 Varieties	甘露排泄量 Amount of honeydew			合計 Total
	高氮區 320 kg/ha.	中氮區 160 kg/ha.	缺氮區 N-deficiency	
Mudgo (RR)	0.58	0.28	0.18	1.04
Kaoshen-yu 12(R)	3.44	2.42	0.39	6.25
T(N) 1 (SS)	8.20	7.22	3.03	18.45
合計 Total	12.22	9.92	3.60	25.74

LSD	5%	1%
(1) Among nitrogen-levels within a variety or among treatments	0.94	1.30
(2) Among varieties within a nitrogen-level	1.23	1.67
(3) Among nitrogen-levels in total of each varience	1.75	2.55
(4) Among varieties in total of each varience	2.13	2.88

a/. 5 重複，各接入雌成蟲 5 隻。甘露量之測定，係依據接入後24小時所產甘露中氨基酸含量比較定之。 5 replications, 5 female-adult insects were caged each for 24 hrs. Amount of

honeydew Produced by the adults was assessed by comparing the total amino acids extracted from honeydew and measuring with spectrophotometer absorbance at 560 mμ.

但無顯著差別。在高秈育12號及臺中在來1號者，則隨氮肥施用量而顯著地增加。在同處理的情況下，褐飛蝨在感蟲品種的排泄量，均顯著地較抗蟲品種爲多。

(三) 壽命及繁殖量 (Life span of adult and increase in population)

將供試水稻之基葉去除後，每一盆水稻接入羽化後2～3日齡成蟲5對，並用網罩（直徑 10cm，高 60cm）罩之。重複5次。接蟲後，每天觀察一次，成蟲在各處理之死亡蟲數，連續15日。在接蟲後30天，每盆水稻以殺蟲藥劑 Unden G 毒死稻株上之褐飛蝨，並計數在各處理之繁殖蟲數(表3)。

表三　氮肥用量對褐飛蝨在抗蟲及感蟲性水稻棲羣增殖之影響

Table 3. Effect of nitrogen fertilizer on the population build-up of brown planthopper on resistant and susceptible rice varieties a/.

品種 Varieties	每株蟲數 Number of insect/Plant			合計 Total
	高氮區 320 kg/ha	中氮區 160 kg/ha	缺氮區 N-deficiency	
Mudgo (RR)	6.20	14.00	1.20	21.40
Kaosen-yu 12(R)	125.00	133.40	16.60	275.00
T(N) 1 (SS)	301.00	244.60	55.80	601.40
合計 Total	432.20	392.00	73.60	897.80

LSD	5%	1%
(1) Among nitrogen-levels within a variety or among treatments	39.64	54.67
(2) Among varieties within a nitrogen-level	42.24	57.24
(3) Among nitrogen-levels in total of each varience	59.42	86.45
(4) Among varieties in total of each varience	73.17	99.16

a/. 每株接入成蟲5對。抗蟲品種之資料採自接蟲後30日，而感蟲品種之資料則採自被害死亡之時。感蟲品種被害死亡之時間，在高氮區、中氮區，及缺氮區分別接蟲後24.2、25.0及22.4日。
Each plant was caged with 5 pairs of adults. Data for resistant varieties were taken 30 days after caging; while for susceptible variety they were taken when the plants were killed before 30 days after caging. The plants of susceptille variety were killed in average of 24.2, 25.0 and 22.4 days after caging for the treatment of 320 kg/ha, 160 kg/ha and N-deficiency, respectively.

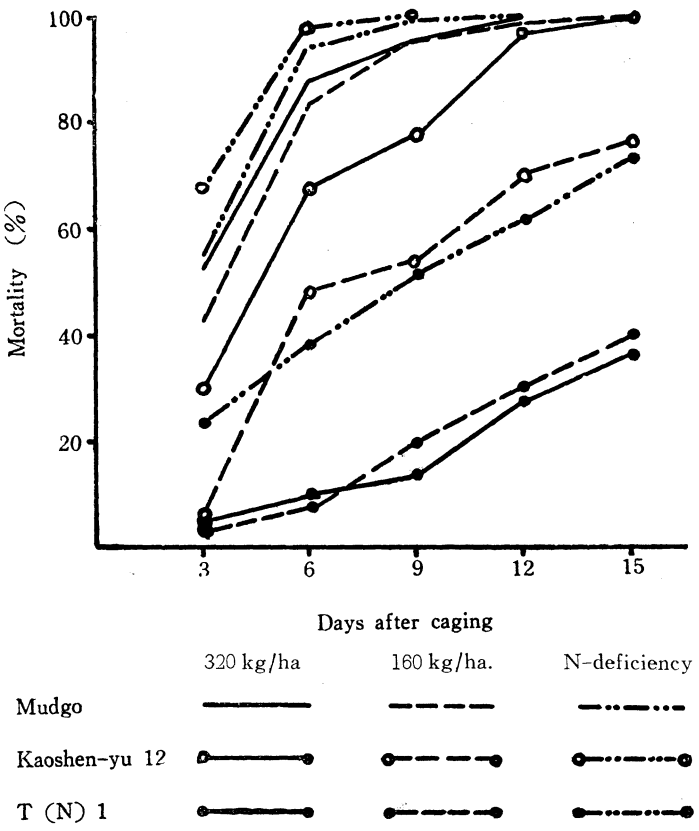
不同氮肥量施用於水稻，對褐飛蝨成蟲壽命之影響如圖4。取食於缺氮區水稻之成蟲，其平均壽命較取食於氮肥處理區水稻爲短。在高氮區及中氮區水稻之成蟲壽命，其差異因品種而不同，在罩蟲後第15日，成蟲於 Mudgo 及臺中在來1號的上述處理之死亡率，前者達98%以上，而後者爲40%左右；但在高秈育12號，兩者相差很大，且取食於高氮區水稻者反較在中氮區者爲短。在三參試品種中，氮肥施用於 Mudgo 水稻對成蟲壽命之影響變異最小，而受影響變異最大者爲高秈育12號。取食於臺中在來1號的成蟲，在同樣處理情況下，其壽命均較其他任何一品種的壽命爲長。

褐飛蝨在不同處理水稻上的棲羣增殖數，無論任何品種，均以在缺氮區水稻上者爲最少（表3）

。在罩蟲後30天，褐飛蝨在 Mudgo, 高秈育12號及臺中在來 1 號等缺氮區水稻上的蟲數，分別為原來接蟲數的0.12、1.66及5.58倍。褐飛蝨在 Mudgo 水稻上的棲羣增殖情況，並未因施用氮肥而有所改觀。反觀在高秈育12號及臺中在來 1 號，於施用氮肥處理區水稻上蟲子之繁殖數量均顯較在缺氮者增加，尤以在臺中在來 1 號繁殖的褐飛蝨，其在中氮區及高氮區水稻上的增殖倍數，竟分別為原來接蟲數的244倍及300倍之高。

圖 4. 施用氮肥於抗蟲及感蟲性水稻對褐飛蝨成蟲壽命之影響。

Fig. 4. Effect on nitrogen application on the life-span of brown planthopper adult on resistant and susceptible rice varieties a/.



a/. 5 replications, each was caged with 5 pairs of 2 to 3- days-old adult.

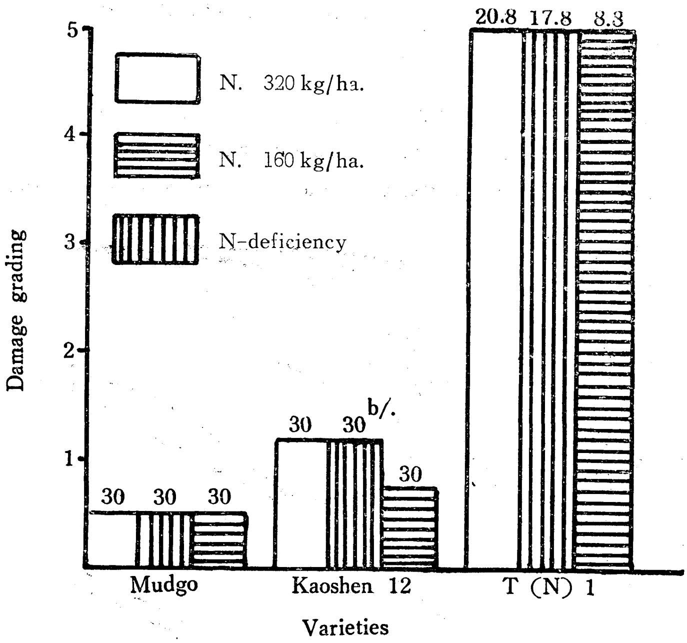
(四) 被害程度 (Plant damage)

經處理30日齡水稻，每盆水稻接入褐飛蝨 2 ～ 3 齡若蟲150隻，並用網罩 (10×60cm) 罩之。重複 5 次。在接蟲後，每三日檢視植株被害狀況一次。在接蟲後30天，以殺蟲藥劑 Unden G. 毒死稻株上之褐飛蝨，並計數其尚存之為害蟲數。

試驗結果如圖 5 。臺中在來 1 號在缺氮區、中氮區及高氮區中，分別在接蟲後平均 8.8、17.8 及 20.8天被褐飛蝨為害枯死。此種結果，從使用殺蟲劑毒死收回之蟲數以觀 (表四) ，顯示品種之抗蟲性，並非隨氮肥的施用量而增加，而是經氮肥處理水稻其生育良好，分蘖較多，對同一數目害蟲為害之容忍性 (Tolerance) 增强而已。

圖 5. 氮肥用量對褐飛蝨在抗蟲及感蟲性水稻爲害之影響

Fig. 5. Effect of nitrogen application on the damage of brown planthopper on resistant and susceptible rice varieties a/.



a/. 5 replications, 150 nymphs are infested each

b/. Date of damage reading.

Grading scale of damage:

0 : No apparent damage to the plant
1 : The lower leaves of the plants show yellow
2 : Half of the whole leaf-blade becomes yellow
3 : Three-fourths of the whole leaf-blade becomes yellow
4 : Half of the testing seedlings are hopper-burn
5 : All seedlings are hopper-burn

表四 褐飛蝨被罩於各處理水稻爲害30天後殘存蟲數之差異比較

Table 4. Number of insect recovered from infested rice plants at 30 days after caging a/.

品 種 Varieties	每株蟲數 Number of insect/Plant			合 計 Total
	高氮區 320 kg/ha.	中氮區 160 kg/ha.	缺氮區 N-deficiency	
Mudgo (RR)	4.60	13.20	4.80	22.60
Kaosen-yu (R)	93.80	113.00	44.00	250.80
T(N) 1 (SS)	129.60	128.80	91.60	350.00
Total	228.00	255.00	140.40	623.40

LSD	5%	1%
(1) Among nitrogen-levels within a variety or among treatments	23.04	32.45

(2) Among varieties within a nitrogen-level	19.17	25.98
(3) Among nirogen-levels in total of each varience	50.89	74.03
(4) Among varieties in total of each varience	33.19	44.98

a/. 每株水稻接入褐飛蝨 2～3 齡若蟲 150 隻。臺中在來 1 號之資料採自高氮區、中氮區，及缺氮區者，分別在接蟲後平均20.8、17.8及8.8日。 Each plant was infested with 150 about 2 nd to 3rd-instar nymphs. Data for T(N) 1 were taken in average of 20.8, 17.8 and 8.8 days after caging for treatments of 320 kg/ha, 160 kg/ha and N-deficiency, respectively.

抗蟲品種於接蟲後30天，無論在缺氮區或氮肥處理區，均未因被害而枯死。在 Mudge 植區，雖因不同氮肥處理水稻的發育及分蘗差異甚大，但處理間之植株被害程度，並無明顯區別，毒死收回之蟲數均甚少。在高秈育12號，缺氮區被害最爲輕微，而高氮區及中氮區被害程度雖較缺氮區爲重，但亦僅四分之一葉片被害黃變而已，從毒死收回之蟲數來看，高秈育12號對褐飛蝨之抗禦性（Antibic-sis）不强。

三、討　　論

寒川報告(16)，水稻施用氮肥有促進褐飛蝨取食、排泄以及棲羣增殖之作用。此項結果，與本試驗在感蟲品種所得之結果一致。褐飛蝨在水稻抗蟲品種之甘露排泄量及棲羣增殖情形，氮肥處理區雖較缺氮水稻上者增加，但區間差異不若感蟲品種之明顯。

褐飛蝨在水稻抗蟲品種及缺氮肥上之取食或排泄量，較水稻感蟲品種上爲少之原因，據寒川等之研究報告(16)(18)，謂非因抗蟲品種稻株組織堅韌，昆蟲不能取食，而可能是因此等水稻所含之游離氨基酸（Free-amino acids） 稀薄，致使褐飛蝨不喜歡取食之故。氨基酸的一種 Asparagine 後來被發現對褐飛蝨取食具有促進作用(17)。但此種氨基酸在缺氮區之水稻無法檢出（尾崎，1954）。因此褐飛蝨取食於缺氮肥水稻減少甘露之排泄量可能與缺乏 Asparagine 有關。至於氨基酸在抗蟲品種所扮演之角色如何，目前未見有詳盡報告；唯從業已有較深入的荳科植物蚜蟲爲害抵抗性的報告，及褐飛蝨在抗蟲品種取食之狀況推測，褐飛蝨取食於抗蟲品種排泄少量之甘露，與抗蟲植物含有少量氨基酸可能亦具有密切關連。 Maltais (9) 分析豌豆（Pea）植物體內氮素含量與品種對荳蚜爲害感受性之關係，發現在感蟲品種氨基酸態氮素含量均較抗蟲品種爲高。此種氨基酸態氮素，後來非但被證明爲蚜蟲之重要營養物質，而且爲支配蚜蟲之取食行動及寄主選擇之主要因素(8)(12)(11)。

本試驗未直接分析抗蟲品種或缺氮肥水稻有礙褐飛蝨正常取食及繁殖的原因。但從各項試驗結果顯示，褐飛蝨在同一品種或處理水稻上取食之排泄量與其對該品種之嗜好性，繁殖量或生存狀況一般具有密切關係。此點可能顯示褐飛蝨取食及生育繁殖是受到同樣或數種具極密切關係的物質所支配，而此種（或此等）物質在感蟲品種隨氮肥的施用量而敏感顯著地增加（或減少）。但在抗蟲品種，尤其是具高度抗蟲性之 Mudgo ，氮肥對此（等）具支配性物質含量的增進效應，似並不如感蟲性品種之明顯。

氮肥對褐飛蝨在水稻上取食及繁殖的影響，因品種反應不一，已如上述。但無論如何，氮肥對水稻本身，具有促進發育及分蘗之特性；而此種特性，在不同氮肥處理之水稻，遭受同等數目褐飛蝨爲害時，具有互異之容忍性。在自然環境下，因施用氮肥之水稻爲褐飛蝨所喜愛取食，且褐飛蝨之繁殖又隨氮肥之用量而增高，致感蟲品種的容忍特性相對減少；但在抗蟲品種，尤其具高度抗蟲性品種，氮肥用量對褐飛蝨在該品種取食或繁殖的影響不大，其容忍性反因促進發育及分蘗而增長；至於中等抗蟲品種，在正常情況下，褐飛蝨並不能大量繁殖而造成嚴重的災害，除非褐飛蝨反常的從外面大量遷入。

四、摘　　要

增施氮肥爲促進水稻發育及增產的主要法門，但由於水稻組織及其所含的營養物質，隨增施氮肥而變得更柔嫩而豐富，更有利於病蟲害的繁殖與侵害。本試驗在探究氮肥施用量與褐飛蝨在水稻取食、繁殖及爲害之關係，尤其着重於氮肥對於水稻抵抗褐飛蝨爲害可能發生之影響。玆將試驗結果歸納如下：

（一）水稻施用氮肥有促進發育及分蘖的效果，但較缺少氮肥時更爲褐飛蝨喜愛而棲息取食，且褐飛蝨在水稻之取食量、排泄量、生存率及繁殖量，均因氮肥施用量增加而增加。此種影響，因水稻品種對褐飛蝨抵抗性不同而差異。例如對褐飛蝨具有高度抵抗性之 Mudgo ，其氮肥施用量之多寡，均不能顯著影響褐飛蝨之取食量、排泄量及繁殖量。

（二）在中氮區（160 kg/ha）及高氮區（320 kg/ha）處理間，除甘露排泄量因氮肥施用量而增減外；他如寄主嗜好性及棲羣增殖，則因水稻之抗蟲性而異。在抗蟲品種，褐飛蝨的棲息、或取食蟲數及棲羣的增殖，在氮肥處理間並沒有顯著的差異；惟在感蟲品種，褐飛蝨在高氮區水稻棲息取食蟲數反較在中氮區爲少。若將褐飛蝨分別罩在上述兩種處理之水稻，不讓其有選擇取食的機會，則在前者之棲羣增殖量較後者爲高。上述兩種現象，反映褐飛蝨在水稻上取食、生存及繁殖，可能受到某種物質所支配。此種物質，在感蟲品種是隨氮肥的施用而增減；在抗蟲品種，氮肥對該「支配物質」含量增減的效應，似較鈍感。在另一方面，此項結果亦顯示植物體內該種「支配物質」的含量有定，供量增加，非惟不能增進褐飛蝨對該物質取食之喜愛程度，且反而降低。

（三）接受不同量氮肥處理水稻，加罩接入同一數目的褐飛蝨，則水稻對被害的容忍性隨氮肥用量而增强。但在自然環境下，褐飛蝨任自活動，因氮肥處理之水稻被較喜愛取食及繁殖感蟲品種，被害之容忍性相對減少，而抗蟲品種氮肥之施用，對褐飛蝨取食或增進的影響不大，被害程度不致有明顯的改變。

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EFFECT OF NITROGEN APPLICATION ON THE SUSCEPTIBILITY IN RICE TO BROWN PLANTHOPPER ATTACK

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SUMMARY

Application of nitrogen to the paddy-field is one of most practical method to increase the yield of rice. However the rice plant treated with nitrogen is usually suffered more infestation by insect or disease pests than untreated one. This experiment is conducted to determine the relationship between the application of nitrogen and the host preference, survival, population build-up and plant damage of brown planthopper on rice plant, with special emphasis upon the possible effect of nitrogen application on the resistant varieties. The results of this study are summarized as follow:

The rice plants treated with nitrogen were more preferred by brown planthopper, and the hopper feeding on nitrogen treated rice plant had more honeydew production, higher survival rate and population build-up than on nitrogen-deficiency rice plant. However, the above mentioned reactions of brown planthopper between two different amount of nitrogen treatments were variable. The brown planthoppers caged on the plant of susceptible variety treated with high level of nitrogen (320 kg/ha) excreted more honeydew and built-up higher population than on low nitrogen treated one(160 kg/ha),but the former was lesser preferred for sheltering or feeding than the latter one when the hopper had chances to choose their host plant. While on resistant varieties, there were not any significant difference of hopper's reactions observed between two different amount of nitrogen treatments. These results seem to reveal that the feeding, survival and multiplication of brown planthopper are ruled by a (or some) element(s) in rice plant, and that "element(s)" in resistant varieties are generally not as sensitive as in susceptible variety response to the amount of nitrogen application. Furthermore, they also reveal that the hoppers are more preferred the moderate "element(s)" content rice plant than that of higher ones even the latter are more nutritious to the insect than the former ones.

Base on another separate test, it revealed that the degree of plant damage was generally related with the reactions of brown planthopper on each treatment. All rice plant in different treatments of susceptible variety, T(N) 1, were hopper-burn within 25 days after they were separately caged with 150 nymphs. Although the tolerance of rice plant to insect attack showed increase with the amount of nitrogen applied in this test, however, this type of tolerance in susceptible variety was not essential important under natural conditions because of the nitrogen treated rice plants generally provided the best conditions for the brown planthopper to build-up its population. In contrast with that, the variety such as mudgo showed adversely to the feeding and multiplication of brown planthopper in all levels of nitrogen tested, therefore, the damage on the plant of this variety did not affected apparently by the application of nitrogen. It was worth to note that the susceptibility of plant in the variety such as kaoshen-yu 12 was more or less affected by the application of nitrogen. In the case of nitrogen-deficiency, the plant of this variety showed as resistant as mudgo, while it was suffered moderately damage when the plant was treated with nitrogen.